Laser Power Meter for Manufacturing Applications

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The official link for this solicitation is: http://www.grants.gov/web/grants/view-opportunity.html?oppId=275010

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Department of Commerce

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Description:

The decreasing cost and increasing efficiency of high-power lasers is revolutionizing manufacturing in the U.S. and around the world. Multi-kilowatt lasers are now routinely used for welding, cutting, and additive manufacturing. Precision control of these processes, and thus the uniform quality of the manufactured product, requires a meter that can measure the power of such lasers with an uncertainty of only a few percent. Historically, NIST’s standards for power measurements of high-power lasers have been massive thermal detectors [1]. While suitably accurate, their size, cost, and technical characteristics (e.g. temporal response) are not optimal for use in manufacturing operations. For example, an important goal is to incorporate a power meter into the head of a laser welder, measuring the output power in real time and without sacrificing laser power or beam quality.

NIST seeks further innovation to improve the state-of-the-art, leading to the commercialization of smaller, faster, and cheaper power meters, which would also have high accuracy. One approach would be a device based on our recent demonstration showing that the inherent force in light (radiation pressure) can be exploited to measure high-power lasers in a manner that could be 1/10th the cost, 10 times the speed, a fraction of the size, and yet with accuracy that is comparable to the existing technology of large thermal detectors [2]. NIST is especially interested in the development of a second-generation radiation pressure power meter.

The goal of the project is to develop a small, fast, rugged radiation pressure sensor capable of

measuring, in situ, high power laser radiation up to 10 kW (5 kW/cm2).

- Small: Dimensions less than 50 mm x 50 mm x 50 mm
- Damage threshold: 5 kW/cm2
- Temporal Response: 10 ms
- Reflectance: Primary reflected beam contains 99.99 % of input
- Robust: Survives acceleration of 3 g, operates with sensor in random physical orientation and in motion (up to 1 m/s).
- Signal processing/data access: by separate (external) processor (Laptop, FPGA, Raspberry PI, etc.)

Phase I activities and expected results:

- Develop suitable force-sensor mechanism (capacitive, current compensation, pressure, etc.).
- Demonstrate performance and calibration of force-sensor mechanism by using calibrated masses, or other means.
- Determine suitable high-reflectance mirror.
- Engineer packaging for small volume and ruggedization.

Phase II activities and expected results:

- Demonstrate temporal response.
- Demonstrate optical power density survivability and thermal management.
- Incorporate pressure sensor (power meter) into a laser-welding head, to demonstrate integration with real-world manufacturing processes.

NIST will be available to assist the awardee by discussing NIST’s research and ideas. The NIST 10 kW laser and laser-welding booth are available for device testing in collaboration with NIST; NIST can aid in determining the accuracy of the developmental power meter through comparison with NIST's Flowing Water Optical Power Meter. Temporal response can be determined by using NIST’s modulated laser source.

References:

1. C. L. Cromer, X. Li, J. H. Lehman, and M. L. Dowell, *Absolute High-Power Laser Measurements with a Flowing Water Power Meter*, presented at the 11th Conference on New Developments and Applications in Optical Radiometry, Maui, Hawaii, USA. (September 19–23, 2011). See also: http://www.nist.gov/pml/div686/laser_power_meter.cfm.

2. P.A. Williams, J.A. Hadler, R. Lee, F.C. Maring, and J.H. Lehman, *Use of Radiation Pressure for Measurement of High-Power Laser Emission*, Optics Letters, 38, 4248-4250. (2013). See also: http://www.nist.gov/pml/div686/laser-102213.cfm.

3. U.S. Patent Application No. 2014/030-7253, *Optical Meter and Use of Same*. See: http://appft.uspto.gov/netacgi/nph-Parser?Sect1=PTO2&Sect2=HITOFF&p=1&u=%2Fnetahtml%2FPTO%2Fsearch-bool.html&r=1&f=G&l=50&co1=AND&d=PG01&s1=20140307253.PGNR.&OS=DN/20140307253&RS=DN/20140307253.

See also: http://tsapps.nist.gov/techtransfer/index.cfm?event=public.techdisplay&ItemID=409